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Three Decades of Anti-evolution Campaign and its Results: Turkish Undergraduates' Acceptance and Understanding of the Biological Evolution Theory

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Abstract Even though in the early years of the Republic of Turkey Darwin's theory of evolution was treated as a scientific theory and taught fairly in schools, despite all the substantial evidence accumulated supporting the theory of evolution since then, Darwin and his ideas today have been scorned by curriculum and education policy makers. Furthermore, Turkish students and academics have been faced with unprecedented creationist propaganda for many years. In this paper, we first provide a glimpse of the theory of evolution and creationism in Turkey, we then report the results of our survey study ($N = 1{,}098$) about the undergraduates' acceptance and understanding of Darwinian evolution and some of the socioeconomic variables affecting those measures. Our cross sectional study shows that acceptance and understanding of the theory of evolution is quite low. We criticize the current state of evolution education in Turkey and call for a change towards a scientific treatment of the theory evolution in schools.

1 Introduction

The theory of evolution has long been regarded as the most important and unifying theory in biology, as expressed in Theodosius Dobzhansky's oft-quoted remark, "nothing in biology makes sense except in the light of evolution" (Dobzhansky 1973, p. 125). Despite the fact that biologists do not dispute the fact that life has evolved (and continues to evolve) on this planet and despite overwhelming evidence in favor of evolutionary theory as the best explanation of this fact, creationist views continue to threaten the teaching of

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biological evolution at all educational levels. At a more general level, creationism also threatens scientific literacy by presenting a distorted image of the nature of scientific theories as if theories were mere speculations to be proven rather than coherent explanations of natural phenomena supported with evidence collected through systematic observations.

In response to increasing creationist propaganda around the globe, academicians have become more alert and defensive against creationist assaults (Alters and Nelson 2002; National Academy of Sciences 1998). In 2006, national science academies in 65 countries declared a position statement in defense of teaching evolution (The Inter Academy Panel 2006). Creationism simply means that all living things on the earth were created by God, and these living things stayed pretty much in their original form (Scott 2005). In addition, a new form of creationism, intelligent design, asserts that universe and living things are designed by an "intelligence" of some sort without reference to the Bible. On the other hand, the scientific theory of evolution broadly asserts that all species including humans represent highly modified descendants of a common ancestor as result of processes that have taken place over geologically long periods of time (Futuyma 2005).

In our study, we first provide a short history of the theory of evolution in Turkey and then the results of a survey study of Turkish undergraduate students' acceptance and understanding of the theory of evolution and relationships between acceptance, understanding and several key socioeconomic variables. We selected our participants from undergraduates majoring in biology, biology education, and elementary science education license programs. We chose them because these are the groups of people who will presumably make the most impact on teaching and learning of evolution theory in the future. Indeed, research indicates those teachers who have stronger knowledge of evolution are more likely to emphasize evolution in their instruction (Aguillard 1999; Rutledge and Mitchell 2002), whereas teachers who have stronger religious convictions are less likely to accept the theory of evolution and therefore less likely to cover it in the classroom (Somel et al. 2006; Trani 2004).

1.1 A Glimpse of the History of Evolutionary Theory in Turkey

The data for this study were collected from 11 public universities across Turkey. Turkey is a developing country with an overwhelmingly Muslim population of over 70 millions. Turkey has a parliamentary democratic system and a secular government. Historically Turkey has close ties with the Western world: Turkish social, economic, and cultural life are greatly influenced by the West. Negotiations between Turkey and European Union for Turkey's accession to the Union have been underway since 2004.

When the Republic of Turkey was founded in 1923, the first president of the republic Mustafa Kemal Ataturk spearheaded a number of initiatives, one of which was the reform in education aiming at unification and secularization of educational systems. Laws associated with this reform eliminated religious schools and introduced the theory of evolution into the biology curriculum (Sayin and Kence 1999). In 1931, the National Ministry of Education published a book on Darwin written by a Turkish Darwinist (Ata 1931) in a series of books on the great personalities printed by the state printing house. In a book outlining Turkish history, also printed by the state printing house in 1930 (Devlet Matbaasi), the first chapter on history of humanity contained discussions on evolution of living things, including humans. Darwinian evolution was then considered as a valid scientific theory and an essential part of the science curriculum. The young republic's positivist education philosophy was best captured in the famous dictum of Ataturk, "the truest guide in the world is the science".

Between the late 1930s and early 1970s there were no major changes in how evolution was taught. Starting from 1972 onward, however, the number of concepts related to evolution covered in biology textbooks began to decrease (Somel 2005). The most dramatic change in approach toward the teaching of the theory of evolution occurred after the 1980 military coup. Creationism was introduced to the biology curriculum by the National Ministry of Education in 1985 in collaboration with the Institute for Creation Research (ICR) from the US. *Scientific Creationism* by Henry Morris (1985) of ICR was translated into Turkish and distributed to biology and elementary science teachers (Kence 1985; Sayin and Kence 1999). Even though Darwin's views on the origins of biodiversity were still in the biology textbooks after the introduction of creationism, it was treated in a ludicrous and non-scientific manner. For instance, the following excerpt is translated from a high school biology textbook published by the Ministry of National Education in 1990:

> After reading this book [Malthus's An Essay on the Principle of Population], Darwin put forward the idea that living things would have to get in a ruthless life-or-death fight for survival. We all know that in nature living things have to struggle in order to survive. However, this struggle cannot be seen as totally wiping out the weak. There are many examples that falsify Darwin's views on nature. The evolutionists who are against Darwin ask, if all weak are eliminated from nature how can we explain the existence of species that appear quite weak to us? For example, how can viruses, bacteria, and some parasites still survive? Humans, who are the most advanced living things, cannot wipe out all bacteria even though they use antibiotics (Guven et al. 1990, p. 71).

In addition to the introduction of creationism to biology textbooks, compulsory religion courses concurrently entered the school curricula. This was part of a systematic effort to create politically more conservative and religiously more fundamentalist generations in an era following the 1980 military coup characterized by an artificial fear of the threat of communism for society (Edis 1999; Sayin and Kence 1999). In 1997, the prime minister of the time made some anti-Darwinist statements; and in 1998 the Science and Research Foundation [Bilim Arastirma Vakfi (BAV)—the leading creationist organization] intensified its campaign against Darwinism and published a large number of anti-Darwinist and anti-evolution books and booklets. Furthermore, the BAV tried to silence scientists defending evolution by vilifying them as Marxists, communists, Maoists, separatists, atheists etc., all of which are depicted as threats against the values of the majority of society (BAV Web site 2009; Heneghan 2006).

Recently, creationism has gained new momentum in Turkey owing to the efforts of some creationist organizations (Special Report 2006). The evolution-creationism debate in Turkey has been extensively covered in national and international media (Heneghan 2008; Steinvorth 2008, 2009). Creationists have used vast amounts of funds in a campaign of defamation against Darwinism and its proponents. One of the most provocative tools of creationist propaganda that originated in Turkey is *Atlas of Creation* authored by Yahya (2006), a leading creationist figure in the Islamic world. *Atlas of Creation* is an over-sized book with over 800 glossy pages, weighing 5.4 kg and as its title proclaims, it promotes creationism. The Turkish government remained silent when the source of the funds at the creationists' disposal was questioned by the press, and as copies of Atlas of Creation were distributed primarily in Europe and most part of the world in many prestigious universities free of charge (Dean 2007).

1.2 Current State of Evolution Education in Turkey

Turkish education system is superintended by the Ministry of National Education and all subject areas have associated national curricula. Up until the 2008–2009 academic year, the 11th grade biology curriculum, in a unit entitled "Views about the Origin of Life", presented the idea of creationism as an alternative view to evolution. Darwin's ideas are covered very briefly (one and a half page including two contextual pictures) without any connection to rest of the biology units. The following excerpt reflects how the idea of creationism is covered in the 11th grade biology textbook:

> According to creationist view, all species were created separately. These species did not turn into other species even though they underwent slight modifications since they had been first created. According to this view, humans and other living things were created separately and at different points of time…In sum, creationist view indicates that the universe operates in an order that is determined by rules of God and this order cannot happen randomly and spontaneously (Sagdic et al. 2003, p. 184)

High school education has recently been extended by adding a year beyond 11th grade, and as of the writing of this essay, the entire high school biology curriculum is now subject to change. Anticipated changes to evolution content have not yet been publicized by the Ministry of Education. Currently the same text of the old 11th grade biology book involving the excerpt above is used to teach biology at the 10th grade level. We do not know if the evolution content will be included in the new 12th grade biology curriculum in a more scientific manner. However, given the political stance of the current administration and its chief education officers who have publicly denounced Darwinism and embraced the idea of intelligent design (Steinvorth 2008), it is hard to be optimistic about the evolution content of new biology curricula.

Even though Turkish constitution guarantees a secular education, all students starting from fourth grade to twelfth grade must take compulsory religion courses (i.e., Culture of Religion and Knowledge of Ethics). This information is critical because an important part of the evolution-creationism controversy in Turkey is centered on the question of how permissive the Turkish education system should be in allowing youth to make free decisions about the essential questions of life (e.g., "Where did we come from?"). While all Turkish students are required to learn the religious doctrines of Islam (with the exception of students from minority non-Islamic families), considerably fewer of these students have access to scientific knowledge of evolution. The reasons for such limited evolution education can be listed as: (1) Students who opt to study non-science fields at high school can graduate with only two hours of biology per week at 9th grade with no mention of evolution theory because evolution is covered only in 11th grade biology which is not part of the non-science course track. (2) Those who select to study science have limited access to a scientific perspective on evolution because the 11th year biology textbook unit "Views about the Origin of Life" introduces the creationism as an alternative idea to the evolutionary theory to explain the origin of living things. Furthermore, the evolutionary theory is not taught as unifying theory in biology curriculum, but rather presented as an isolated "view" about the origin of life among some other non-scientific views. Indeed, it is ironic that the central theory of biology has essentially become the most marginalized idea in the Turkish biology curriculum owing to its placement as part of the last unit taught at a time when most high school students are absent owing to their preparations for a national university entrance exam. (3) Not surprisingly many biology teachers are uncomfortable teaching evolution because they feel the pressure of communities that oppose the teaching

of evolution, and also there are biology teachers who do not accept the theory of evolution at the first place; and therefore, they are reluctant to teach it (Somel et al. 2006).

According to Somel et al. (2006), more than half of the biology and elementary science teachers in their study did not accept evolution theory, either partially or at all. Interestingly, the acceptance of evolution theory among veteran teachers who have at least 20 years of service and those who have less teaching experience differs significantly. Since the 1980s, recent generations of teachers have been raised in a political milieu where creationism is praised and the theory of evolution is bashed, which explains the lower rates of acceptance of evolution among relatively young teachers. Similarly, a more recent survey shows 95% of the teacher candidates enrolled in a particular teacher education program over the last 17 years indicated that they were not taught evolution in high school (Ergezen 2007).

Public acceptance of evolution theory in Turkey is considerably lower than in other European countries. According to an international poll conducted in the US, Japan, and some European countries, Turkey ranked last among 34 countries in public acceptance of evolution (Miller et al. 2006). The reported public acceptance rate in that study was below 30%. In addition, in a recent report, only 25% of participating students, faculty and staff at a public university in Turkey accepted the statement that humans descend from earlier animal forms as true (Tolon et al. 2008).

1.3 Research on Learners' Views of Evolution

There are two distinct constructs in our study: acceptance and understanding of evolution. "Acceptance" will be used in our study with reference to how a learner evaluates claims about evolution (e.g., whether evolution occurs or not). "Understanding of evolution", in contrast will refer to a learners' conceptual comprehension of the theory of evolution (Cobern 1994). It has been argued that, unlike acceptance of the evolution theory, the understanding of evolution theory can happen without abandoning one's worldviews (Demastes et al. 1995). Some research has shown that understanding and acceptance are related to each other, that is the better the understanding of nature of science and evolutionary theory a teacher has, the more likely he or she will accept the theory of evolution (Deniz et al. 2008; Lombrozo et al. 2008; Rutledge and Warden 2000). However, the direction of the relationship between acceptance and understanding is not well understood (Sinatra et al. 2003). As Sinatra et al. 2003 put it, which one comes first? Is it understanding of the evolution theory initially that results in the acceptance of it later or vice versa? Other research has found no relationship between level of understanding and acceptance of evolution theory (Bishop and Anderson 1990; Sinatra et al. 2003).

Previous research on learners' acceptance of evolution theory documented that there are multiple factors that influence learners' acceptance of evolution theory. Some of these factors include learners' reasoning level, thinking dispositions (Deniz et al. 2008; Sinatra et al. 2003), religious and worldviews (Cobern 1994), views of the nature of science (Lombrozo et al. 2008) epistemological views (Deniz et al. 2008; Sinatra et al. 2003), and understanding of the evolutionary theory (Rutledge and Warden 2000; Sinatra et al. 2003). Factors like these and also learner's motivation and attitude are together often called learner's "conceptual ecology" of evolution theory (Demastes et al. 1995). Recent research shows that even what a learner perceives as consequences of evolution theory (e.g., increased selfishness, decreased spirituality, etc.) might influence his/her acceptance of evolution theory (Brem et al. 2003). In our study, we aimed at understanding the relationship between the acceptance and understanding of evolution theory and how some socio-economic variables affect those measures.

Studies in Muslim societies have shown that those who acknowledge evolution often interpret it in support of their religious beliefs. Most Muslims believe the goal of science is to provide proof of the existence of Allah and evaluate scientific evidence with reference to their knowledge of Islam (Dagher and BouJaoude 1997). As reported by Ashgar and Alters (2007), Muslim scientists and teachers do not see a problem between evolution and Islam because they do not see the scientific evidence as challenging to their religious view but rather confirming it. In this regard, Edis (2004) highlights an interesting point about how the creationist views, particularly idea of intelligent design meshes well into Islamic philosophy. In Islam it is believed that spirutal reality shapes material reality. In light of this, it is not suprising that a materialistic explanation of the origin of life would not get approval from Islamic clergy and laypersons; whereas intelligent design (where mind precedes matter) would.

1.4 Significance of the Study

Recently, Turkish pre-service teachers' views on biological evolution theory were studied from a "conceptual ecology" perspective (Deniz et al. 2008), and several reports about the Turkish people's views on evolution were disseminated (Miller et al. 2006; Tolon et al. 2008). However, these studies are problematic in that they either had a relatively small sample size or did not have a sample that was representative of geographical extent and diversity of Turkey. The present paper reports the results of a survey of a large sample representing a geographic and demographic cross section of potential biology (grades 9–11) and elementary science (grades 4–8) teachers in Turkey. Our study analyzes the potential effects of several factors on undergraduate students' acceptance and understanding of the evolution theory that have not been studied extensively in Turkish context such as year at university, major of study, type of high school graduated, parents' level of education, etc. Finally, we also attempted to mesh our results in a critical overview of the Darwinism and evolution education in Turkey.

2 Methods

2.1 Research Questions

The following research questions are at issue in this study: (1) To what extent do Turkish biology, biology education and science education majors accept and understand the evolutionary theory? (2) What is the relationship between students' acceptance and understanding of the evolutionary theory? (3) What are the effects of some socioeconomic and demographic variables (e.g., income level, parents' education level, access to the Internet at home, size of the city where enrolled university is, gender) on students' understanding and acceptance of the evolutionary theory? (4) Are there differences between freshman and senior students with regard to acceptance and understanding of the evolutionary theory?; and (5) Are there differences between students who desire to know more about evolution and those who do not with regard to their acceptance and understanding of the evolutionary theory?

2.2 Participants and Settings

Participants of this study were 1,098 freshman and senior undergraduate students enrolled in three different undergraduate programs, namely biology, biology education,

and elementary science education in 11 public universities of Turkey. (The number of participants referred to below, however, appears different where pairwise and listwise methods were used.) Table 1 represents the distribution of the participants by gender, program and year in the program. Because of the centralized structure of higher education in Turkey, all undergraduate programs have the same core curriculum. All freshman students in our study took similar general biology courses that are offered in two parts, one in the first and the other in the second semester of their programs. Senior level students, however, differed in their course tracks. Biology and Biology Education students took the similar range of compulsory biology courses (e.g., cytology, microbiology, zoology, plant physiology, genetics etc.). Senior students in elementary science education program took fewer biology courses than their counterparts in the other two programs. However, they took a wide variety of introductory level science courses from different disciplines. In biology programs, the course on evolution is part of the core curriculum offered in the fourth year. It should be noted, however, that the content and scope of this course are greatly varied by universities (Basibuyuk 2007). In Turkish higher education system no creationist elements are formally imposed by the Higher Education Council; however, individual instructors may choose to incorporate creationist views into their instruction.

2.3 Survey Instruments

We administrated a three-part survey. The first part was consisted of 16 questions concerning demographic and socioeconomic variables. Those variables included in the current study are gender, year at the college, type of high school graduated, parents' level of education, family income level, number of books at home, regular Internet access at home, ownership of a PC, and size of the city where the enrolled university is located.

The second part was a Turkish adaptation of the Measure of Acceptance of the Theory of Evolution (MATE, Rutledge and Warden 2000) instrument. The original MATE

Table 1 The distribution of the participants by gender, major fields, and year in major fields

Gender	Major field	Year	*N*
Female	Biology	1st	278
		4th	170
	Science education	1st	57
		4th	85
	Biology education	1st	30
		4th	32
Female total			652
Male	Biology	1st	139
		4th	162
	Science education	1st	41
		4th	69
	Biology education	1st	15
		4th	20
Male total			446
Grand total			1,098

instrument has 20 items; and it is a five point Likert type instrument. Participants were given five choices for each item: strongly disagree (1), disagree (2), undecided (3), agree (4) and strongly agree (5). For descriptive results, we combined all agree (4 and 5) and disagree (1 and 2) responses in their respective categories. Among 21 items, 12 negative items were converted prior to the analyses. For each item, scientifically most consisted choice was given 5 points and other choices were scored accordingly. Possible scores for the instrument ranged between 21 and 105. Three items in the original MATE insturment were taken out in the Turkish version, and four new items were added. To make the MATE Turkish context more relevant, we replaced the two items related to the age of the earth and one related to Bible with items about Adam and Eve, Noah's Ark, and Qur'an. Furthermore, we added an item about the common misconception that "evolution theory cannot be a law because it has not been proven". We found a .91 Croanbach alpha value for the internal consistency of Turkish version of the MATE. The following are some sample items from this survey: (1) Organisms existing today are the result of evolutionary processes that have occurred over millions of years. (2) Modern humans are the product of evolutionary processes that have occurred over millions of years. (3) Much of the scientific community doubts if evolution occurs. (4) Evolution is not a scientifically valid theory and (5) Adam and Eve were the first human beings lived on the earth (This item is not in the original MATE instrument).

The third and last part of the survey was a knowledge test that measured students' understanding of evolution theory and it included 12 questions. We selected these questions from an existing evolution test (Johnson 1985 as cited in Rutledge and Warden 2000). The questions were about the following concepts: natural selection, homologous structures, genetic variation, intermediate forms, speciation and reproductive success. The following is an example question we included in the test.

The evolutionary theory proposed by Charles Darwin was:

A. Change in populations through time as a result of mutations.
B. The spontaneous generation of new organisms.
C. The passing on of genes from one generation to the next.
D. Change in populations through time as a response to environmental change.
E. The development of characteristics by organisms in response to a need.

Each question had only one correct answer and student scores varied from 0 to 12 for this test.

The surveys were mailed to the course instructors who were teaching either a freshman or senior level course in one of the 11 universities included in our study universities across Turkey. We found those instructors either on the web pages of universities or through personal networks. Upon receiving official permissions from the faculty administrations, course instructors helped us to administer surveys. Students participated on a voluntary basis. Because of unpredictable bureaucratic processes, we were not able collect our data synchronously across all universities. The data were collected throughout the academic year of 2007–2008.

The variable about the type of high school (HS) graduated included six categories: Straight HS, Anatolian HS, Science HS, Teacher HS, Anatolian Teacher HS, and Vocational HS. After 8 years of compulsory basic education, students can continue their HS education in a wide variety of schools. HS placements were used to be made through one-step nationwide standardized test. As of 2008 this one-step test is no longer required for HS placements; placements are instead now made with reference overall academic performance at middle school. Except for students in the Straight HSs, all student placements in

the other five types of HS are based on how they score on a nationwide test. Among HSs, the Science HSs are considered to be the most prestigious and selective ones because they have an intensive science curriculum and were founded to raise future scientists. The Anatolian HSs have English as the language of instruction. The Anatolian and Anatolian Teacher HSs are better alternatives to the Straight HS and the Teacher HS, respectively, because they usually have higher achievement rates. The Teacher HSs of any type aims at preparing students for teacher education programs at college and the Vocational HSs prepares technical work force in a wide variety of fields. Although there was a category of Anatolian Vocational HS in our survey, no participant fell into this category; and as such, it was excluded from the analysis.

2.4 Analysis

All raw data were recorded into computer environment and descriptive and inferential statistical analyses were made by using the Statistical Package for the Social Sciences (SPSS) Version 15.0. Means, standard deviations, and frequencies were calculated as descriptive statistic. As inferential statistic, the bivariate correlation analysis, two-way analysis of variance (ANOVA), one-way ANOVA, planned comparisons, bivariate regression, and independent-samples *t*-test were performed to address different research questions. A bivariate correlation analysis was conducted to assess the relationship between understanding and acceptance of evolution. A two-way ANOVA was conducted to find differences among the students' major fields with respect to understanding and acceptance of evolution. One-way ANOVAs were also performed to identify possible differences in students' levels of understanding and acceptance separately with respect to year in program, major of study, socio-economic variables (e.g., family income, level of education), and type of high school graduated.

Planned comparison analyses were additionally conducted among three major fields for freshman and senior levels separately with regard to understanding of the evolutionary theory. Mothers' education levels were also subjected to planned comparisons with respect to acceptance of the evolutionary theory. Bivariate regression analysis was conducted to reveal the relationship between level of acceptance and level of mother education.

Independent-samples *t*-tests were conducted separately for the acceptance and understanding levels of evolution with regard to following independent variables: gender, ownership of a PC, having regular access to the Internet at home, size of the city where the enrolled university is located, year at university, and desire to know more about the evolutionary theory.

3 Results

3.1 Descriptive Results

When all participants were pooled, the percentage of students who accepted and rejected evolution was 27.9 and 20.7, respectively, with 51.4 of students undecided about whether evolution occurred. These percentages emerged in response to the first item in the MATE instrument: "Organisms existing today are the result of evolutionary processes that have occurred over millions of years". Table 2 represents percentage of acceptance, rejection and undecided categories by major field and year in program.

Table 2 Percentage of students who rejected, accepted, and were undecided with respect to major field and year in program

Major field	Year	Rejected (%)	Undecided (%)	Accepted (%)
Biology	1st	17.4	55.1	27.5
	4th	17.9	50.5	31.7
Science education	1st	35.9	43.6	20.5
	4th	20.2	54.3	25.6
Biology education	1st	34.2	42.1	23.7
	4th	17.5	45.0	37.5

3.2 Understanding of Evolution

When the data on "understanding" were subjected to two-way ANOVA where major field [F (2, 1,082) = 10.32] and year in program [F (1, 1,082) = 64.99] were the two factors being considered, both factors and their interaction [F (2, 1,082) = 15.87] were highly significant ($p < .001$). Since there was a highly significant interaction between the two factors, we conducted a one-way ANOVA taking the major field as a factor and carried out the analysis for freshmen and seniors separately.

Among freshman, major field does not appear to have a significant effect on students' understanding level of the evolutionary theory ($p > .05$), whereas the same figure was significant among seniors ($p < .001$). We compared groups according to planned comparison (Pedhazur and Schmelkin 1991), where the first comparison was between biology majors and education majors (biology and science education) and the second comparison was between science education and biology education. Our hypothesis was that students who are exposed to the evolutionary theory more in their program of study would develop a better understanding of the evolutionary theory. According to this hypothesis, we expected that students would be ranked in the following order based on their understanding levels, starting from the highest level: biology, biology education and science education. Understanding did not differ between biology majors and education majors among freshmen [t (189.06) = .64, $p > .05$]. On the other hand, significant differences were observed among seniors [t (133.24) = 6.41, $p < .001$]. When we compared the students in science education with students in biology education, they did not differ among freshmen. However, they differed among senior students [t (69.65) = 4.25, $p < .001$]. Senior level students ranked in the following order based on their understanding scores, starting with the highest level, biology education, science education and biology (see Table 3).

3.3 Acceptance of Evolution

The results of two-way ANOVA where major field [F (2, 784) = 6.20] and year in program [F (1, 784) = 9.51] were two factors revealed that both factors had significant effect on acceptance scores ($p < .01$). However, no significant interaction was found between these factors [F (2, 784) = 1.97, $p > .05$]. When we compared the plots of means of acceptance in two different year levels, we detected some tendency of interaction although it was not significant. Therefore, we decided to follow same analysis for acceptance as in the understanding. The difference between biology majors and education majors in the acceptance scores was highly significant among freshmen [t (126.89) = 3.61, $p < .001$], whereas there was no significant difference in the acceptance scores between biology

Table 3 The sample sizes, means, and standard errors with respect to understanding and acceptance of the theory of evolution for students in different major fields and years

Variable	Major of study	Year	*N*	*M*	SE
Understanding	Biology	1st	413	5.22	.09
		4th	326	5.54	.10
	Science education	1st	98	5.25	.17
		4th	154	6.08	.12
	Biology education	1st	45	4.98	.22
		4th	52	7.44	.30
Acceptance	Biology	1st	287	64.90	.79
		4th	218	66.03	.10
	Science education	1st	78	59.18	1.79
		4th	129	63.64	1.32
	Biology education	1st	38	58.55	2.36
		4th	40	65.68	2.52

majors and education majors among seniors [t (384) = .80, $p > .05$]. In addition, we found no difference between science and biology education majors. The sample sizes, means, and standard errors of understanding and acceptance of evolution depending on major fields and year in program are given in Table 3.

The bivariate correlation analysis was conducted to assess the relationship between understanding and acceptance of the evolutionary theory and Pearson product-moment correlation coefficient was medium size ($r = .25$).

3.4 Socioeconomic Factors

We measured the effect of socioeconomic factors on students' understanding and acceptance of the evolutionary theory by using the following parameters; number of books, ownership of a PC, regular access to the Internet at home, family income, and parents' level of education. The number of books at home did not have any effect on the understanding [F (5, 1,076) = 1.68] and acceptance [F (5, 780) = .90] levels of the participants ($p > .05$). Owning a PC at home had a significant effect on understanding [t (1,090) = 1.90, $p < .05$]; however, it did not affect the level of acceptance [t (789) = .08, $p > .05$]. Regular access to the Internet at home had highly significant effect on both the understanding [t (1,087) = 3.57] and acceptance [t (787) = 4.66] of levels of the evolutionary theory ($p < .001$). Family income level did not have any effect either on understanding or on acceptance of evolution ($p > .05$).

We conducted a one-way ANOVA in order to see the effect of parents' education level on the understanding and acceptance levels of the evolutionary theory. The father's education level had no effect either on understanding or on acceptance of evolution. We found no significant effects of mother's education level on students' understanding of evolution. On the other hand, mother's education level significantly affected [F (4, 776) = 4.03, $p < .01$] participants' acceptance level of the theory of evolution. We further examined the effect of mother's education on students' acceptance levels by making the following planned comparisons: (1) illiterate versus primary school education, (2) illiterate versus middle school education (3) illiterate versus high school education, and (4) primary,

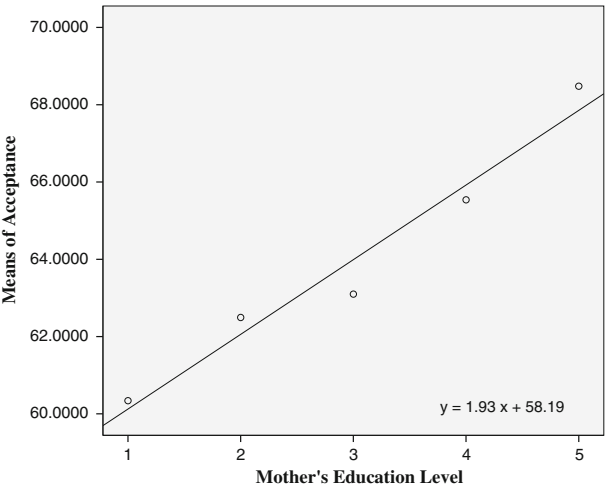

Fig. 1 Regression of means of acceptance of evolution on mother's education level. *Note*: The numbers on the *x*-axis mean the following. *1* Illiterate, *2* primary school, *3* middle school, *4* high school, *5* university

middle, high school education versus university education. We had the hypothesis that the children of more educated mothers will accept the theory of evolution more than the children of less educated or illiterate mothers. In the first and second comparisons, we found no significant effect on the level of acceptance of evolution ($p > .05$). We found a significant effect on the acceptance level in the comparison between illiterate and high school educated mothers ($p < .05$). When we contrasted mother's level of education between primary school, middle school, and high school versus university education, there was a significant effect on the acceptance of evolution ($p < .01$). As seen on Fig. 1, when the means of acceptance were regressed on the level of education in mothers, we found highly significant regression coefficient [t (3) = 5.96, $p < .01$].

3.5 Gender

An independent-samples *t*-test was conducted to evaluate the hypothesis that there is a mean difference between female and male students with regard to the levels of understanding and acceptance of evolution. The test was not significant [t (1,091) = .017, $p > .05$] for understanding, but the test revealed significant differences between males and females for the acceptance level of the evolutionary theory [t (672.83) = 4.20, $p < .001$].

3.6 High School Type

There was a significant effect of the type of high school graduated on understanding of the theory of evolution [F (5, 1,075) = 3.41, $p < .01$] and post-hoc analysis showed that the mean scores of understanding between students who graduated from the Anatolian and the straight high schools differed ($p < .05$). On the other hand, the type of high school did not show a significant difference on acceptance scores [F (5, 777) = 1.71, $p > .05$]. The sample sizes, means, and standard errors of understanding of evolution depending on high school graduated are provided on Table 4. The highest mean score of understanding was observed in Science HS followed by Anatolian HS, Anatolian Teacher HS, Straight HS, Vocational HS, and Teacher HS.

Table 4 The sample sizes, means, and standard errors of understanding and acceptance of evolution depending on high school graduated

Type of high school	Understanding			Acceptance		
	N	*M*	SE	*N*	*M*	SE
Science HS	7	6.86	1.01	5	69.80	6.85
Anatolian HS	223	5.87	.13	171	65.54	1.21
Anatolian teacher HS	23	5.65	.37	17	57.06	3.65
Straight HS	816	5.46	.06	581	63.87	.59
Vocational HS	9	4.78	.68	6	71.17	5.10
Teacher HS	3	3.67	.88	3	71.00	3.06

3.7 City Size

We also compared the levels of understanding and acceptance of the theory of evolution with respect to the size of the city where the students' enrolled universities is located. We compared two cities, Istanbul and Ankara, which are distinctively larger than the rest, with the other cities in our sample. We found highly significant difference between major cities and other cities in understanding [t (1,091 = 5.69, $p < .001$]. When we further examined this difference within freshmen and seniors only, we found a significant difference among seniors [t (530) = 5.87, $p < .001$]. However, no difference was observed among freshmen [t (554) = 1.22, $p > .05$] with respect to the size of the city where the university education is received.

The acceptance level of the evolutionary theory did not show significant difference between major cities and others [t (790) = 1.31, $p > .05$]. Additionally, among freshmen there was no significant difference in the acceptance level [t (401) = 1.10, $p > .05$] while the acceptance level of evolutionary theory among seniors enrolled in universities in large cities was significantly higher than the students who were receiving their university education in other cities [t (385) = 2.22, $p < .05$].

3.8 Difference Between Freshmen and Seniors

When we examined the whole sample through independent samples t-test to see if there is a difference between freshmen and seniors we found a significant mean difference in the scores of understanding [t (1,086) = 6.16, $p < .001$]. However, the acceptance scores of students did not show any difference [t (788) = 1.92, $p > .05$].

3.9 Desire to Know More About Evolution

The overall percentage of students who indicated that they have desire to learn more about the evolutionary theory was quite high at 86.6%. An independent-samples t-test was conducted to see if there was a significant mean difference between students who have desire to learn more about the theory of evolution and who do not in the scores of understanding and acceptance of evolution. The result showed that the desirous students have significantly better scores of understanding [t (1,066) = 2.87, $p < .01$] and acceptance [t (776) = 10.21, $p < .001$] than the undesirous students.

4 Discussion

Our results indicate that acceptance of evolution among biology, biology education and science education majors is not any different from previously reported public acceptance rates of evolution (Miller et al. 2006; Tolon et al. 2008). Overall, 27.75% acceptance rate of evolution theory is disappointing. When we look at the same figure among freshmen alone, situation is even worse: only 23.9% of them accepted evolution theory. When we compare acceptance rates of the students in our study with students from the US (Ingram and Nelson 2006)—the US was the penultimate country above Turkey in Miller et al.'s 2006 ranking of public acceptance of evolution-, we see a substantial difference. Undergraduate students in Ingram and Nelson's study accepted evolution in rates above 60% before not taking an evolution course, and 70% and above after taking an evolution course. In addition, Gross and Simpson (1982) reported 54% acceptance rate for the theory of evolution among American students who were taking introductory level biology courses in 1976. While Turkey and US have very close public rates of acceptance, the rates of acceptance among biology or biology related programs are quite remarkable. We attribute this difference to the ill-structured high school biology curriculum (Turkey is the only secular country where creationism is being taught along with evolution in its high schools as a state policy) and lack of scientific standards in evolution education in most universities in Turkey. Accountability in evolution education is also highly questionable in Turkish universities (Basibuyuk 2007). For example, one of the authors of this paper witnessed an instructor who taught evolution course through a textbook (Tatli 1992, Tatli is a well-known creationist academic in Turkey) that frequently refers to Qur'an, the holy book of Islam. Anecdotal evidence indicates that there are a number of instructors who teach evolution in unscientific manners in Turkish universities.

The results indicated that one's acceptance level of evolution is very unlikely to change at college level. However, improving understanding of evolution theory seems to be relatively easier than changing acceptance. Students' acceptance level of the evolutionary theory remained highly stable across most independent variables. For example, among seniors, level of acceptance did not differ by the major of study. In addition, students' acceptance level did not change significantly by the number of books at home, family income level, ownership of computer, father's education level, type of high school graduated, and size of the city where the enrolled university is located. Only regular Internet access at home and mother's education level, and gender were found to be effective on students' acceptance level. Recent sociological research shows that Turkish mothers' education level and cultural background are two important factors that accounted for the schooling rates of their children at primary and secondary levels (Smits and Hosgor 2006). The same reasons that accounted for the schooling might have been valid for the students' acceptance of evolution.

Unlike acceptance, the understanding of the evolutionary theory is varied by more independent variables. In particular, understanding scores of seniors appears to be stratified by their major of study. Interestingly those majoring in biology education and science education had better understanding levels than students majoring in biology did. This may reflect long-lasting unemployment problems in Turkey: teaching license programs are perceived to be better job prospects than most programs in science colleges, and therefore it may be more difficult to compete for entrance into a biology education program than a biology program. As such, the overall academic achievement of those students who earn entrance into science education programs might be better than those who enter science programs when they begin college.

One of the most interesting findings of our research was the effect of high school type on students' understanding level of evolution theory. We found a significant effect of high school type of on students' understanding overall; however, a posteriori test did not reveal any differences among individual school types. The ownership of a PC and regular access to the Internet are both found to be increasing students' understanding of the evolutionary theory. Regular access to the Internet also accounted for increase in students' acceptance level. Although there are much more creationist web sites than those evolutionist in Turkish language, one way of explaining the positive effect of the Internet on students' understanding and acceptance levels can be that those who have regular Internet access at home are happened to be more open to new ideas and have more chances to discover ideas about evolution theory that are not covered at school.

Another interesting finding is that we found significantly higher rates of understanding scores among students who were enrolled in universities in large cities in comparison to those enrolled in universities of relatively small cities. The universities in Istanbul and Ankara where we collected data were among the largest and oldest higher education institutions in the country and had stronger research and education programs than the institutions in other cities. As result of this, students in large institutions could have benefited better instruction of the evolutionary theory. In addition, we can speculate that in large and cosmopolitan cities there is less community pressure on instructors who teach evolution, whereas in small communities the pressure is higher.

We found that acceptance of evolution is higher among females than males. This result is similar to Gross and Simpson's (1982) and Tolon et al.'s (2008) results that females have higher attitudes toward evolution theory than males. However, the number of studies that investigated gender factor is limited in evolution education research and it is difficult to interpret these results without considering other variables associated with gender.

We also found that students who have more desire to learn about the theory of evolution have better understanding and acceptance level of the evolution theory than those who do not want to learn more about the evolution theory. These results suggest evolution instruction probably would not make much of a difference on students who adamantly reject the theory because they would not show the interest and the effort to learn it. Conversely, students who initially accept the theory of evolution and have a desire to learn more about it can benefit more from the evolution instruction.

5 Conclusion

Our results clearly indicate that the radical change in approach towards teaching the theory of evolution in the last three decades resulted in a very low rate of acceptance of the theory of evolution among biology, biology education, and science education majors in Turkey. Over 50% "undecided" responses in our survey can be attributed to lack of scientific treatment of the theory of evolution in high schools and some universities. Our results suggest that undergraduates need better evolution education in order to make more informed decisions on the questions about the origin and history of life.

Currently most students at K-12 and beyond in Turkey are not provided with a scientific understanding of the origin and history of life. We believe that when students are deprived of theory of evolution their democratic right to learn about the scientific account of the origin of living and non-living things is taken away. Turkish biology curriculum should be revised by the elimination of creationist statements and the inclusion of more accurate information about evolution. It should also emphasize the centrality of the theory of

evolution throughout primary and secondary education. The theory of evolution should be the guiding theoretical lens in interpreting and explaining biological phenomena, rather than being a marginalized idea confined to the last chapter of a biology textbook.

Similarly, in order to be more accountable biology programs Turkish higher education institutions should carefully question the practice of pro-creationist academia. Despite the intense and widespread creationist propaganda in the last 10 years, the efforts of Turkish academia in defence of the evolution theory have been sporadic and short. Only a few systematic efforts have been put underway to fight against creationism (Somel et al. 2007). We believe it is an ethical responsibility of biologists and science teachers to promote the theory of evolution or any other scientific theory for that matter over pseudoscience. One and a half century after the publication of the Darwin's *The Origin of Species*, finding only about one quarter of science and biology teacher candidates accepting the evolutionary theory is disconcerting for science educators and unpromising for the future of evolution and science education in Turkey.

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